Intermediary bank behavior and debt structure under asymmetric information

Yida Kuang

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Department: School of Economics
Supervisor: Prof. Martin Kaae Jensen
Prof. Yoshi Morozumi

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Abstract

This dissertation is aim to built a foundation for the future study. It reviews past literature on the intermediary bank behavior and debt structure under imperfect information market and detailed review a model describing the interaction between intermediary bank and risky firms and adopting credit reallocation and agency problem. Then I present the for a extension version which would be one of the baseline for the future study, and compare technical solutions which the different results due to the change of settings.

1 Introduction

Modigliani and Miller (1958) theorem is a well known and influential theorem that states that the channels and forms through which firms finance expenditure do not affect the expected return of the firm under perfect market conditions, which include conditions of perfect information. While other perfect market conditions remain crucial, the impact of imperfect information started to attract attention since the paper 'The Market for Lemons' (Akerlof, 1970) illustrates how the market malfunctioned due to imperfect information. The existence of asymmetric information between buyer and seller regarding product quality results in an average quality weighted price and drives out some of the good sellers, and the seller anticipates that and further reduces quality, which drives out more good sellers. Eventually, this leads to market collapse.

The asymmetric information could also arise between intermediary banks and firms; for example, there could be asymmetric information about the firm's output, which could be costly for lenders to verify. For market efficiency, there requires some mechanisms to describe the strategic interactions between intermediary banks and firms and solve the asymmetric information problems. This is my research interest at the current stage. However, this requires knowledge of both intermediary banks' and firms' dynamic interaction under an asymmetric information market, which is far beyond my ability at the current stage. Therefore, in this dissertation, I concentrate my focus on the bank behavior part and the technical solution. The discussions in the literature I have illustrate mainly the topics related to intermediary bank behavior, including intermediary banks' behavior and contract structure under asymmetric information and how they could be affected by maintaining a long term relationship between intermediary banks and firms. I adopt and convert the setting of Keuschnigg and Kogler (2020), which is a one period static model, to feature an infinite period and belief updating as one of the baseline models for future study. The different time settings in the models end in a different result. Keuschnigg and Kogler (2020) characterize Schumpeterian type banks where creative destruction arises by withdrawing loans from less productive firms and reallocating them to more productive firms. The revelation of a firm's true type allows the intermediary to reallocate loans, and the process of liquidation is costly. This cost creates distortions in intermediary banks' optimal loan allocation and reduces the degree of improvement in aggregate output due to the existence of intermediary banks. In the extended model, since intermediary banks' beliefs are updated period by period after observing the firm's project outcome, there will not be credit reallocation within one period, but instead across periods. As a result, compared with Keuschnigg and Kogler (2020), the intermediary bank will augment the improvement in aggregate output in the extended version, but this improvement still faces limitations due to costly capital arising from agency problems and minimum capital requirements.

The structure of the rest part of this dissertation is organized as follows: In section 2, I will review some of the previous literature related to the future work which includes the topic of intermediary banks' behavior in an asymmetric information market. In section 3, I will present a review of Keuschnigg and Kogler (2020) and discuss the implications for capital cost and agency problem. In section 4, I will focus on the technical solution in the extended version of Keuschnigg and Kogler (2020) and discuss the differences in results. In section 5, I will discuss the plan for further study since this dissertation is not a finished work; instead, it is the first small step for me and many tasks need to be carried out for the study of dynamic interaction between intermediary banks and firms in an asymmetric information market. Finally, in section 6, I will give a brief summary of this dissertation.

2 Literature Review

2.1 Introduction

In this section, I illustrate the previous discussions in the literature in line with the topic in the model section and future studies, which relate to intermediary bank behavior. I mainly focus on the topic of debt contracts with asymmetric information, the role of bank capital, the motivations for long term relationships between intermediary banks and firms, the agency problem, and the impact of policy intervention as a solution.

2.2 Delegation Monitor

Townsend (1979) raises the point that real world contingent dealings among agents are fewer than theoretical models, such as the Arrow Debreu model, suggest, largely due to information asymmetries and are therefore associated with the concept of verification costs, stating that verification of the state is costly and thus affects the design and feasibility of optimal contracts. In the paper, Townsend (1979) first develops a model with two agents in which agent 1 is endowed with a fixed amount of resources and agent 2 is endowed with a random resource that is only freely observed by the agent itself. Agent 2 can issue an asset to agent 1 to guard against the uncertainty arising from its random endowment. The key innovation is costly state verification, which refers to the idea that the true state of the endowment can only be known by agent 1 at a cost paid by agent 2. Based on the project outcome observed, agent 1 chooses whether to verify and the amount of payment. Townsend demonstrates that in Pareto optimal contracts, there must be a balance between the benefits of state verification and its costs. This leads to contracts where agent 2 reports truthfully with no verification and situations where verification and state contingent transfers are necessary.

Diamond (1984) provided one of the first explanations to answer the question of why financial intermediaries exist: they monitor the borrowers. In this paper, the intermediary bank raises funds from depositors, promises them a specific rate of return, and lends to firms, paying the cost for monitoring. Due to ex post asymmetric information, where the firm's real output is not freely known by the lender, it is necessary to monitor the firm. Also, the lender is disadvantaged since without appropriate incentives, the firm might not fulfill its promise. To solve this issue, Diamond introduces the non-pecuniary penalties, which refer to penalties where the entrepreneur's loss does not provide any direct benefit to the lenders, for borrowers failing to pay at least the promised payment. However, monitoring is costly and it could be very high if there are many outside lenders for a firm; delegating this task to an intermediary, such as a bank, is efficient. This sounds as if the lenders should also monitor the intermediary bank, but in this paper, the intermediary bank does not need to be monitored because it bears the penalties for any default payment from the firm to lenders. The diversification strategy of intermediary bank portfolio building ensures the intermediary bank has the incentive to obtain information and stabilize the financial system. Diversification is the core intermediary banks' strategy in this model and it will solve the "monitoring the monitor" problem. The models in Diamond (1984, 1996) do not include all the characteristics of intermediary banks such as the principal agent problem , which in this case describes the situation where the lenders and intermediary banks have different goals. Mainly he explains the reason for the existence of intermediary banks: to avoid redundant monitoring and unnecessary costs. In these models, due to the existence of asymmetric information, direct fi-

nance is inefficient and strictly dominated by delegated monitoring since intermediary banks offer a lower cost solution to deal with the asymmetric information problem.
Gale and Hellwig (1985) developed a model of credit contracts. It is a contract between firms that need to raise funds to proceed with production and the financial intermediaries that supply these funds. They mainly focus on the contracting issue and do not address the financial intermediary problem and the features of market equilibrium. This paper shows that the optimal contract is a standard debt contract which is a contract that states a fixed amount of repayment will be made by the firm to its lenders if the firm has enough resources, and if not, the firm needs to enter bankruptcy procedures and liquidation to allow its lenders to recoup the highest possible amount of debt from the firm. It appears that Gale and Hellwig are inspired by the implicit contract models (ICM) and apply some features of these models to credit market imperfections. One difference between this model and ICM is the timing; in this model agents make lending decisions before the output is realized and available for verification rather than after. The model can be viewed as a model incorporate features of risk sharing, asymmetric information and verification costs. Same as in the ICM, asymmetric information plays an important role in this model, but the agent can pay a cost to get access to the information originally not observable. The action of verification is considered as bankruptcy since the optimal contract is a debt contract and the firm's true state needs to be verified only if the firm cannot repay its loan.
Williamson (1996) has presented a model describing an environment with finite agents acting as lenders and firms and introduces asymmetric information about the firm's output. Same as Diamond's model (1984), firms need to borrow from the lenders to proceed with production, which gives the firm a random output in the next period, and this random output follows a distribution. Only the firm itself can freely observe the real output, and for other agents who want to know the true output, they must bear a cost. But all agents know the density function of this random variable. The lending contract specifies terms that if the output reported by the firm to the lender is below some threshold, the lender will pay the cost to monitor; otherwise, there will be no monitoring. In the case where no intermediary bank exists, duplication of monitoring occurs, and in order to improve this efficiency, some lenders need to be assigned to play the role of intermediary bank to improve market efficiency. And the result in Diamond (1984) applies here: by diversification, the lender does not need to monitor the intermediary firm because the intermediary can achieve the promised return for sure. Unlike Diamond, the model in this paper does not rely on such non-pecuniary penalties to ensure the firm does not default if it actually has a high output. In Townsend (1979), the borrower pays the cost to reveal the true outcome to the lender. The verification process occurs after the outcome of the borrower's production is determined and also after a payment has been proposed to the lender. In Diamond's model, monitoring is not contingent on the state of the project. The monitoring cost is inevitable regardless of whether the borrower's project outcome. In Diamond's framework, this cost arises because monitoring is inevitable and must happen before anyone can observe the outcome of the borrower's project. Williamson's (1986) monitoring mechanism follows Townsend's, so we can see that the timing of monitoring will not affect the conclusion of the "monitoring the monitor" problem in Diamond's paper (1986). Krasa and Villamil (1992) focus on the problem of monitoring the monitor since it could be argued that, in reality, the intermediary banks cannot infinitely diversify their portfolios; therefore, the credit risks cannot be fully diversified. Costly state verification has been adopted in this paper, and the cost for depositors to monitor large intermediary banks is higher compared to monitoring smaller intermediary banks due to the intermediary bank size difference. The cost of monitoring the monitor is assumed to linearly increase with the intermediary bank size. Krasa and Villamil

(1992) use the Large Deviation Principle to demonstrate that if the chance of default drops to zero and can be considered fast enough, the expected cost of lenders to monitor the monitor will go to zero. Even for banks with a finite and relatively small size which have not perfectly diversified risk, the gain from delegated monitoring strictly dominates direct investment.
Winton (1995) develops a similar model as in Williamson (1986) but focuses on the role of intermediary bank capital on delegated monitoring. The intermediary bank holds debt contracts with both lenders and firms. The bank capital can be treated as a cushion that can absorb losses, therefore decreasing the chance of bank default and thus the need for monitoring the monitor. In this paper, each intermediary bank's capital is equal to its initial endowment; therefore, capitalization is particularly beneficial for smaller intermediary banks. Larger intermediary banks have a better diversification portfolio but the power of capitalization weakens. In addition, capital becomes more crucial compared to diversification as systematic loan risk increases.
Markovic evaluates the role of bank capital under the BGG framework and retains all of the main features unchanged. There are six types of agents in the model, including: the households, the banks, the entrepreneurs, the capital producers, the retailers, and the government. The households allocate their savings between deposits and bank shares; a cost occurs when households invest in new bank shares due to asymmetric information. The banks collect deposits from households and provide loans to entrepreneurs while maintaining the required level of capital. The lending contract between banks and entrepreneurs is based on the costly state verification model, where banks pay a cost to verify a firm's true output. The banks are not indifferent between bank capital and deposits due to the cost difference, and this difference is crucial in determining the required return on bank capital. Three bank capital channels are identified in this paper: the first channel that may lead to change in cost of bank capital is the capital loss channel, which arises due to the change in the price of bank shares. The second channel is the adjustment cost channel, which arises due to asymmetric information; new investors need to pay an adjustment cost to investigate the bank before investing in it. The third channel is the default risk channel, which arises due to the change in expected bank default risk, and it varies with economic cycles. All these three channels will require banks to pay a higher dividend to their shareholders and therefore drive up the bank capital cost. The simulation results suggest that bank capital channels significantly influence the monetary transmission mechanism, particularly during periods of large shocks to bank capital. The increase in the cost of bank capital will lead to higher lending interest rates, reduced borrowing, and lower output.

2.3 Long Term Relationship

The literature discussed in the above section focuses on one period interactions where there exists a probability that firms will under perform and trigger the action of intermediary banks to monitor the firms. The following literature discussed in this section will demonstrate the impact of building long term relationships between the intermediary bank and the firm.
Haubrich (1989) provides one of the first insights on the impact of long term relationships on monitoring costs. The paper sets up a theoretical model that follows Diamond's model (1984) and illustrates the interaction between risk neutral and free time preference intermediary banks and firms under long term relationships. The main idea incorporated by Haubrich (1989) is that long term relationships can induce the Revelation Principle, which ensures it is optimal for all firms to truthfully reveal their outcomes. Since for firms, it is not profitable to over report the outcome; if they under report and get detected by the bank, it will affect their reputation, and they will not

receive loans for a period of time. A test is set by the bank to detect the under reporting firms but does not hurt the firm that truthfully reports but has bad luck on the project return. Since in this model intermediary banks have no time preference, which implies absolute patience, and the bank can keep track of their reports over time, the threat of damage to reputation and losing future funding is enough to encourage the borrower to report truthfully and therefore further reduce the intermediary bank costs of monitoring. Although tracking the histories of firms' project outcomes still involves some level of cost, this cost of tracking the outcome history is surely lower than the cost of knowledge needed to obtain to fully understand a firm. Therefore for intermediary banks, maintaining a long term relationship with firms is still beneficial since the cost of monitoring is relatively lower than the cost of monitoring required for a one period relationship as in Diamond's (1984) setting.

Boot et al. (1994) consider another source of impact: the long term relationship and firm reputation on the bank's behavior, with the motivation derived from the bank promising when reaching reputation maturity. Boot et al. (1994) developed a theoretical model for understanding the structure of bank loans by considering the moral hazard problem in an infinite period market and without the belief updating process and risk sharing process. The model is built on an infinitely repeated game between intermediary banks and firms in a competitive bank loan market. In each period, the firm borrows funds from the intermediary bank to invest in a project, where the success rate is ex ante identical but will be ex post different due to the different effort costs the firm pays on the project, and yields either a positive return if successful or zero if failed. The firm's effort cost selected for the project is private information, leading to the moral hazard problem. Each firm has a certain level of assets that can be used as collateral to secure a bank loan. In each period, each firm faces two types of contracts: the risky loan and the collateral based loan. The process of a firm accumulating reputation plays a important role in this model , which enables the change of loan structure in the absence of belief updating process and risk sharing process. In a one period game, the first best can only be achieved if the firm selects to accept a collateral based loan and the motivation of the firm to inject more effort is the fear of loss of its collateral. While in a game repeated for more than one period, the intermediary bank provides another motivation for firms to inject more effort on the project, promising a subsidy on project success. The subsidy that the intermediary bank promises in the future will increase the current price of the loan as compensation, and for a firm to accept it can be seen as accepting a process of accumulating reputation. Maintaining the long term relationship will benefit the firm since it will be offered a lower loan price. The result shown in the paper suggests that the intermediary bank will consider a firm reputation matured after one successful project and all firms can achieve their first success in a project within a finite period of time.

Petersen and Rajan (1995) consider the long term relationships under different bank loan markets. In the paper, Petersen and Rajan (1995) evaluate the long term relationship in a concentrated credit markets where few lenders dominate the market and in a highly competitive credit markets. In the model setting, there are two types of firm: good firm and bad firm and both of them need to borrow funds from the intermediary bank to invest in a project. The good firm have two options on the project invest with different risk and returns and the bad firm always fail in the project and earn nothing. The intermediary banks are set initially only know the proportion of firm's type but will fully know firm's type after one period. Since the intermediary bank do not know the firm's true type, there exist a pooling equilibrium where the good type borrow the minimum amount in order to reduce the cost of funds since the price of loan is higher in period one due to the uncertainty on interest returns and the bad type follow the good type's action. In a highly competitive

credit market, the intermediary bank cannot capture future surpluses generated by firms and interest charge by the intermediary bank will base on the proportion of type and loan risk but this rate may be too high and force small or young firms to choose high risk and low return projects which may can deter small or young firms from obtaining credit and is less conducive to form a long term relationships. However, in a highly concentrated banking market, the intermediary bank can initially offer lower rates, and expecting to recover the losses in the later period by charging a higher rates to good firm as they already reveal their type. In this case, the initial low interest rate would lessen the firm's risk shifting behaviors and is beneficial for the small or young firms. Petersen and Rajan (1995) then conduct an empirical analysis using U.S. National Survey of Small Business Finances data from 1988 to 1989 for the data of small firms and Herfindahl index for the measure of the level of local bank market concentration. The empirical evidence presented in the paper supports the conclusion in the model that young firms are more likely to receive loan offers in less competitive credit markets.

Numerous empirical evidence indicated a positive gain in long term relationship for both intermediary banks and firms. Adamson, Chan and Handford (2003) find that in a market with competition between intermediary bank, a long term relationship is beneficial for both side and in particular, the clients are benefit more from this relationship than the intermediary bank. And the clients' commitment to a long term relationship is largely affect by intermediary bank's market strategy, reputation and trust concern. One of the result in Dass and Massa (2009) suggest that for the firm which treated as good firm and can easier to built long strong relationship with bank will be benefit the most at the early period of this relationship. Aristei and Gallo (2016) use a detailed firm-level dataset across 7 European countries to analysis firm bank relationships and firm's financial conditional. The result indicate that the younger and smaller firms are considered as bearing more risk due to lack of information available in the past. In addition, the number of relationships firm maintain with banks mainly depends on its financial fragility. The credit limit and the demand on credit forcing firm to maintain multiple relationships with banks.

2.4 Agency Problem

This part of the literature discusses the agency problem and the legal enforcement in line with the agency problem in the model section where intermediaries could cheat the creditor and divert profit due to asymmetric information regarding the return rather than the type of agency problem related to the interaction between intermediary banks and borrowers where intermediary banks can threaten to withdraw loans in order to gain a higher proportion of surplus as in Rajan (1992).

Ellingsen and Kristiansen (2011) construct a tractable corporate finance model under the assumption of imperfect contract enforcement. The main goal of this study is to explain that debt contracts are an efficient way used to prevent intermediaries from misappropriating project returns, with probabilistic enforcement and constrained penalties. In the model, they assume that intermediaries could divert project returns and legal protection is only an imperfect protection against such diversion. For simplicity, this model focuses on leniency towards small crimes and enforcement uncertainty, and pays close attention to how the risk of non-equilibrium transfers affects contracts. The optimal contract gives the intermediaries enough profit in each state to compensate them for not diverting. The proportion of profit transferred to intermediaries depends on the probability of detection and the level of punishment.

As the previous literature (Tirole, 1999) pointed out, the incomplete contract literature has largely overlooked the issue of contract enforcement. While enforcement is a central concern in models of

relational contracts, the likelihood of legal enforcement is typically not considered.
One of the first study on legal enforcement is LA PORTA et al. (1997) which address the impact of legal enforcement on agency problems between firms and investors. They conduct an empirical study on cross country differences and use a 49 country data sample finding that countries with poorer investor protections, which are determined by legal regulation and the quality of law enforcement as the weighted measure of investor protections, have less developed capital markets.
Giannetti (2003) explores how firm characteristics, legal regulations, and financial development influence intermediaries' behavior and decisions across eight European countries. By utilizing firm level data from the Amadeus database, the study highlights the significant role that regulatory institutions play in shaping agency problems. Specifically, Giannetti (2003) suggests that in countries with strong lender protection, firms investing in intangible assets without collateral find it easier to secure loans. Moreover, the protection of lender rights is particularly crucial for firms in sectors with highly volatile returns, as it enhances their access to long term debt. In particular, this benefit applies to listed firms more since the listed firms can leverage their visibility to issue new bonds, resulting in lower leverage and longer debt maturities compared to unlisted firms, even after controlling for various firm characteristics. Giannetti (2003) further demonstrates that institutions that highly value lender rights and ensure stricter enforcement regulations often tend to be associated with higher leverage and greater access to long term debt. The study also finds evidence that only firms in well capitalized countries could increase leverage.
Kvaløy and Olsen (2009) demonstrate how legal institutions can influence trust based environments by incorporating endogenous verification ability into a relational contract framework. Kvaløy and Olsen (2009) analyzed a repeated game of agency problem to examine how variations in institutional approaches and the effectiveness of legal enforcement impact outcomes. In this game, the principal makes a specific investment by paying the agent in advance and expecting an agreed return with good quality. In the model, the game is repeated, hence the principal could safeguard the agent's investment by threatening to terminate the relationship if the agent abuses her trust. Additionally, they could build a well detailed contract to note the quality. This could be used to increase the probability of court verification. The principal faces trade offs, since both quality and verification are costly.

3 Review on Model

3.1 Introduction

This section presents a review of the paper 'The Schumpeterian role of banks: Credit reallocation and capital structure' (Keuschnigg and Kogler, 2020), which is the main reference I followed in the model section. The paper studies the Schumpeterian role of banks where creative destruction arises by withdrawing loans from less productive firms and reallocating to more productive firms and identifies the distortions in bank behavior. The main result is that, in order not to violate capital requirements, intermediary banks are required to attract ex ante capital investment from the investors to absorb the non-negligible cost arising during the bank loan reallocation process. Moreover, the costly capital shadow price due to the existence of agency problems limits the number of loans that intermediary banks reallocate to more productive firms. The agency problem in this model is in line with the Ellingsen and Kristiansen (2011) discussed in section 2 and the setting of capital match with Winton (1995).

3.2 Model Description

The model set up by Keuschnigg and Kogler (2020) incorporates three stages in one period and three types of agents: investors, entrepreneurs, and intermediary banks. The investors choose the allocation of endowed wealth to investment products to build an investment portfolio. There are a total of three investment products investors could invest in: the first is a deposit in the intermediary bank account, the second is an investment in intermediary bank equity, and the third is an investment in a risk free product. The intermediary bank promises a rate of return to its depositors and a dividend to its shareholders. The risk free asset will give the investors a return r where $r \geq 1$. The entrepreneur runs the firms and owns no wealth, and they need to borrow funds from one of the M intermediary banks to undertake a production project. There are two types of projects: a basic project at period 1 and an expansion project at period 2, both of which require a unit of funds to proceed. There are two outcomes for both types of projects: if successful, they yield output y_x where $x \in 1, 2,\ y_1 > y_2$ and yield nothing if unsuccessful. In total, the intermediary bank provides n loans. The investment returns are assumed to satisfy that $y_1 > 2r > y_2 > r$. The success probability q_i for the i^{th} firm is assumed to follow a uniform distribution $p_i \sim U[0, 1]$. The success probability for a firm is the same for both projects. At period 1, only the firm's distribution of the type is well known by all the agents, and at period 2, the firms' type can be observed. Conditional on the observed type, the intermediary bank withdraws the funds lent to the firm with a low success probability with a cost c where $c \in [0, 1]$ and provides these funds to firms with high success probability to proceed with the expansion project. If $q1 \geq qi$, the firm's expected probability of success falls below threshold $q1$ which implies a high level of risk, the bank will pay the cost of liquidation and recover $1 - c$. If $q2 \geq q_i > q1$ which implies an acceptable level of risk, the bank maintains the loans for the basic project to the firm but will not provide a loan to the additional project. If $qi > q2$ which implies a low level of risk, the bank will maintain the loans for the basic project and offer a loan to the additional project to firm i. Both $q2$ and $q1$ are optimally determined by the intermediary bank. The intermediary bank imposes a gross interest ix depending on both types of projects.

The timing of the model is illustrated below:
1. In period one, intermediary banks raise deposits and equity from investors, entrepreneurs start a firm, borrow funds from a bank with an interest i_1, and invest in a basic project.
2. In period two, intermediary banks observe the firm's success rate and liquidate loans for the firm with low success probability and provide these funds, which are deducted after the cost of liquidation, to the firm with higher success probability for the expansion project and charge an interest i_2.
3. In period three, projects mature and firms with successful projects repay their debt and the intermediary bank pays promised interest to its depositors and dividends to the investors. Investors and entrepreneurs consume all income they received.

Since the intermediary bank use $(1 - c)q_1 n$ recovered funds to finance $(1 - q_2)n$ units of expansion loans in period 2, the budget constraint for reallocated funds is:

$$q_2 = 1 - (1 - c)q_1 \equiv q_2(q_1), \quad q_2'(q_1) = -(1 - c) < 0 \tag{1}$$

The increase of the threshold q_1 tightens the success probability required for the basic project and will relax the required success probability for the expansion project and provide more loans avail-

able for the expansion project. After the reallocation process, the final loan size $n^{'}$ shrinks to

$$n' = (1 - q_1)n + (1 - q_2)n = (1 - cq_1)n < n \tag{2}$$

Once the project is successful, the firm will repay the loan. Since the project success probability for each firm is uniformly distributed, the expected success probability for each project type is:

$$\overline{q}_1 = \frac{\int_{q_1}^{1} q dq}{1 - q_1} = \frac{1 + q_1}{2}, \quad \overline{q}_2 = \frac{\int_{q_2}^{1} q dq}{1 - q_2} = \frac{1 + q_2}{2} \tag{3}$$

The intermediary bank's interest income $\bar{i}$ is equal to:

$$\bar{i} = \overline{q}_1 i_1 (1 - q_1) + \overline{q}_2 i_2 (1 - q_2) \tag{4}$$

And the intermediary bank's profit is the interest income minus the promised return paid to its depositors. Since in equilibrium, the investors should be indifferent between the three investment products, the promised return of deposits is equal to the return of the risk free asset r.

$$\pi^b = \bar{i}n - rd \quad n = d + e \tag{5}$$

The capital in this model plays a similar role as in Winton (1995), to absorb cost of reallocation. The minimum capital requirements on bank loans are the key regulatory constraint. Let the intermediary bank's minimum capital ratio be k, and let the required capital on each loan made to the expansion project be k. Since the risk of the expansion project is lower, the required capital on each loan made to the expansion project is wk, where $w \leq 1$. In period 2, the withdrawal cost reduces the equity by $cq_1 n$, and the capital requirement falls by $kcq_1 n$. Then, since there are $(1-c)q_1 n$ loans reallocated to the expansion project, the capital requirement increases by $wk(1-c)q_1 n$. Given this prediction, the intermediary bank in period one needs to ensure the equity raised in period 1 satisfies:

$$e \geq kn + bq_1 n, \quad b \equiv \max\{(1 - k)c - k(1 - w)(1 - c), 0\} \tag{6}$$

The entrepreneur always prefers to join the market and accept any loan offered since in period two the firm may receive additional loan for the expansion project or remain the basic project yield a positive return $q_i(y_x - i_x)$ or liquidated yields nothing. The expected firm profit is

$$\pi^f = \overline{y} - \bar{i}, \quad \overline{y}(q_1) \equiv \overline{q}_1 y_1 (1 - q_1) + \overline{q}_2 y_2 (1 - q_2), \tag{7}$$

The marginal effect of a higher liquidation threshold q_1 is equal to

$$\overline{y}'(q_1) = (1 - c)q_2 y_2 - q_1 y_1, \quad \overline{y}''(q_1) = -(1 - c)^2 y_2 - y_1 < 0 \tag{8}$$

Setting $q_1 = 0$ we have $\overline{y}'(q_1) = (1 - c)y_2 > 0$ and $q_1 = \frac{1}{2-c}$ we have $\overline{y}'(q_1) = q_1[(1 - c)y_2 - y_1] < 0$. Increasing the threshold for the basic project from a low level will increase the expected output since the basic project with a low probability of success $q_1 y_1$ is replaced by the expansion project with a high probability of success $(1 - c)q_2 y_2$. However, the marginal gain is decreasing and the marginal cost of credit reallocation is increasing with the increase in threshold up to the threshold limit $\frac{1}{2-c}$.

Similar with the setting in Ellingsen and Kristiansen (2011). The equity holders face an agency problem that the intermediary bank may divert the profit. The reason why the bank does not

divert more than its profit is that dishonoring the promise to the depositors will lead to non-pecuniary penalties imposed on the bank, and the non-pecuniary penalties are significantly large and undesirable. In the paper, equity holders can detect a diversion with probability p and once the bank diverts and is detected by the equity holders, the bank will need to return all the profit it diverted. If the equity holders do not detect the diverted profit, the bank will consume the profit. In order to prevent a diversion, equity holders need to pay part of the profit as compensation and it needs to satisfy:

$$(1-z)\pi^b \geq (1-p)\pi^b \iff z \leq p. \tag{9}$$

After compensate the bank $(1-z)\pi^b$, the equity hold receive the rest of profit $z\pi^b$ as dividend and since in equilibrium, the return of investment products is same, therefore:

$$z\pi^b = re \tag{10}$$

Once the success probability of all firms is observed, the bank decide the optimal threshold q_1 for credit reallocation and to achieve interest income maximization:

$$\bar{i} = \max_{q_1} \left[\bar{q}_1 i_1(1-q_1) + \bar{q}_2 i_2(1-q_2) + \theta\left(e - kn - bq_1 n\right)/n\right] \tag{11}$$

where θ is the multiplier. The optimal condition requires $\theta b = -q_1 i_1 + q_2 i_2(1-c)$, rearrange gives the optimal interest for each type of project

$$i_1 = \frac{(1-c)q_2 i_2 - \theta b}{q_1}, \quad i_2 = \frac{q_1 i_1 + \theta b}{(1-c)q_2} \tag{12}$$

Consider the capital structure, in period 1 the intermediary bank attracts investment in deposits and equity and makes loan offers to the firms to maximize profit. The contract on equity related to dividends requires the intermediary to maximize dividends and equity holders' surplus s^o subject to the constraint addressing the agency problem. Let μ be the multiplier and we have

$$S^o = \max_{z,e,n} \left(z\pi^b - re + \mu(p-z)\pi^b\right) \tag{13}$$

The optimal share of bank profit as dividend satisfies $\frac{dS^0}{dz} = (1-\mu)\pi^b = 0$, which gives $\mu = 1$ and implies $p = z$. The optimal size of loans satisfies $\frac{dS^o}{dn} = [\bar{i} - r - \theta(k + bq_1)] = 0$. The optimal equity satisfies $\frac{dS^0}{de} = p\theta = (1-p)r$. Combined together this implies that the intermediary banks will expand loan size until the expected interest income equals the marginal cost of increasing one more unit of funding in equilibrium.

$$\bar{i} = \overline{r} + \theta b q_1, \quad \theta = \frac{1-p}{p} r, \quad \overline{r} \equiv r + \theta k. \tag{14}$$

The shadow price of equity relative to deposits θ, decrease with the probability of bank diversion without detected $1-p$ and increase with the expect return of deposit r. $\overline{r}$ denote the costs of each loan offer to firm when the bank's capital ratio is on the minimum level required. In the constraint equilibrium under competitive bank loan market, the liquidation rate are determined in a way that maximizes expected firm profit.

$$\pi^f = \max_{q_1} \bar{q}_1 y_1(1-q_1) + \bar{q}_2 y_2(1-q_2) - \bar{r} - \theta b q_1 + \theta\left(e - kn - bq_1 n\right)/n \tag{15}$$

The optimal threshold will let the marginal expected gain on output equal to the marginal cost of the capital required to compensate the capital losses during the process of credit reallocation.

$$q_1 = \frac{(1-c)y_2 - \theta b}{y_1 + (1-c)^2 y_2}, \quad q_2 = \frac{y_1 + (1-c)\theta b}{y_1 + (1-c)^2 y_2}. \tag{16}$$

Given these and the optimal interest rate derived above implies that under a competitive market, the intermediary banks proportionately sacrifice level of interest income and transfer this profits to entrepreneurs until they reach to the break even.

3.3 Summary

Compared with the case of direct finance, the existence of intermediary banks improves aggregate productivity. Since intermediary banks can proceed with a capital reallocation process, withdrawing funds from less productive firms to more productive firms will increase aggregate output, while due to the cost of withdrawing funds and the unit size of funds required for the loan, there will be more inefficiency in a direct finance environment. The high shadow price θ relative to deposits reduces the improvement that intermediary banks make on aggregate output since it motivates the intermediary to limit its demand on equity by reducing the threshold q_1, withdrawing fewer funds from the less productive firms and therefore allocating less to the more productive firms. Both adjustments to the capital requirement to a more risk specific requirement and imposing protection of bank equity holders against the intermediary bank would help to stimulate reallocation and improve aggregate production.

4 The Model

4.1 Introduction

In this section, I illustrate an extension of Keuschnigg and Kogler (2020). Keuschnigg and Kogler (2020) developed a static model that describes the interaction between intermediary banks and risky firms, featuring credit reallocation, capital requirements, and agency problems, while I extend it as a benchmark model constructing dynamic environments and adopting a Bayesian belief updating process. The extended version illustrated in this section is expected to be one of the benchmark models of future work on studying the dynamic interaction between intermediary banks and firms in a market with asymmetric information. The main difference compared with Keuschnigg and Kogler (2020) 's single period static model with three stages and the model in this section adopts infinite periods of time and infinitely living agents. The cost of reallocation arises in Keuschnigg and Kogler (2020) due to the revelation of firms' true type in the second stage before the investment project matures, leading to credit reallocation within the period. The intermediary banks withdraw loans from the basic project from firms with low probability of success and reallocate them to firms with high probability, and a cost of withdrawal arises. In the model described in this section, since the intermediary bank's belief in the firm's type will not update before the outcome of the project is realized, there does not exist a credit reallocation process within each period but rather reallocation period by period along with the belief updating process, and the reallocation cost does not exist. The absence of reallocation cost leads the analysis in this

model to a different direction compared with Keuschnigg and Kogler (2020). In Keuschnigg and Kogler (2020), the intermediary bank reduces credit reallocation when facing costly capital, and an amount of loans is still offered to the low productive firms, while in this model, offering loans to the more productive firms requires less costly capital reserves; therefore, the intermediary banks have a strong incentive to offer loans for expansion projects to highly productive firms. Compared with Keuschnigg and Kogler (2020), the bank's behavior in this model results in higher aggregate output since loans are offered to high productivity firms.

4.2 The Model Structure and Equilibrium Analysis

The time is infinite and agents lives forever in this model. Same as the work of Keuschnigg and Kogler (2020), there are three types of agents: investor, intermediary bank and entrepreneur. Only the investors own capital and investors are endowed with same amount of wealth l in each period. They make decisions on the proportion of wealth allocation to different investment products to built investment portfolio. The investors choose allocation of endowed wealth to bank deposit d which yield a promised return, bank equity e which yield a promised dividend and a risk free asset A which yield risk free return r where $r \geq 1$. At the end of each period, the agents will consume all the income they receive. For simplicity, in line with the setting in Keuschnigg and Kogler (2020), the market is set to be a competitive bank loan market to avoid account for monopoly power. The entrepreneur run the firms and own no wealth, requiring them to borrow funds from one of the M intermediary banks in order to undertake a production project. With one unit of funds borrowed from the intermediary bank, the firm could undertake either a basic project 1 yield y_1 if success and nothing if failed or a expansion project 2 yield y_2 if success and nothing if failed. Let $y_1 > y_2$, implies decrease in returns. The success probability θ_i for the ith firm can be treated as a firm's type and follows an uniform distribution $\theta_i \sim U[0, 1]$. For each firm, the two types of project have same success probability. The firm's type is a private information but the distribution of the type and the history of the state of the firm's project is well known by all the agents. The intermediary bank lend all the resources n it received from the investors to the firms based on the intermediary bank's belief on each firm's type and charge a interest i which depend on the type of project in return if the project is success.

The timing of the model in each period is illustrated below:
1. The investor determined investment portfolio.
2. The intermediary bank provide loan contract to finance worthwhile firm's production project which specify the required interest based on the type of project.
3. The outcome of the project revealed, firms with successful project repay their debt and intermediary bank pay promised interest to its depositor and dividend to the investors. Investors and entrepreneur consume all income they received.

Different from the original setting in Keuschnigg and Kogler (2020), since the intermediary bank's belief on firm's type will not update before the outcome of the project is realised, there do not exist a credit reallocation process during each period but rather reallocation period by period along with belief updating process. The decision of loan for the both project is made simultaneously after the intermediary bank receive funds from the investor and depends on the bank's belief of firm's type.
I follow the approach in Zhang and Mahadevan (2000) and Bayes' theorem to describe the inter-

mediary bank's belief updating process. Since the intermediary bank know the distribution of the firm's type, the prior probability of success in period 1 $Pr(S_{i,1})$ for ith firm is the sum of weighted product of all possible type and the correspondence successful rate.

$$q_{i,1}^E = Pr(S_{i,1}) = \sum_{i=1}^{m} Pr(\mu(\theta_i)) \int_0^1 Pr(S_{i,1}|\theta_i, \mu(\theta_i)) f(\theta_i|\mu(\theta_i)) d\theta_i \tag{17}$$

where $\mu(\theta_i)$ is the prior belief of the firm's type and $Pr(\mu(\theta_i))$ is the degree of belief of the firm's type. Let $Pr(\gamma(\theta_i))$ be the joint probability combining the prior belief of the firm's type and with the prior distribution of the firm's type

$$Pr(\gamma(\theta_i)) = Pr(\mu(\theta_i)) f(\theta_i|\mu(\theta_i)) \tag{18}$$

After period 1, there exist firm's full history of the project $h_{i,t-1}$ can be observed by intermediary bank and the posterior joint probabilities given by Bayes' theorem become:

$$\begin{aligned} Pr(\gamma(\theta_i)|h_{i,t-1}) &= Pr(\mu(\theta_i)|h_{i,t-1}) f(\theta_i|\mu(\theta_i), h_{i,t-1}) \\ &= \frac{Pr(h_{i,t-1}|\gamma(\theta_i)) f(\theta_i|\mu(\theta_i)) Pr(\mu(\theta_i))}{\sum_{i=1}^{m} Pr(\mu(\theta_i)) \int_0^1 Pr(h_{i,t-1}|\theta_i, \mu(\theta_i)) f(\theta_i|\mu(\theta_i)) d\theta_i} \end{aligned} \tag{19}$$

Integrating $f(\theta_i|\mu(\theta_i))$ we can have the posterior degree of belief of the ith firm's type $Pr(\mu(\theta_i)|h_{i,t-1})$:

$$Pr(\mu(\theta_i)|h_{i,t-1}) = \frac{Pr(\mu(\theta_i)) \int_0^1 Pr(h_{i,t-1}|\gamma(\theta_i)) f(\theta_i|\mu(\theta_i)) d\theta_i}{\sum_{i=1}^{m} Pr(\mu(\theta_i)) \int_0^1 Pr(h_{i,t-1}|\theta_i, \mu(\theta_i)) f(\theta_i|\mu(\theta_i)) d\theta_i} \tag{20}$$

By dividing equation (3) and equation (4), we can have the posterior distribution of type given a specific history

$$f(\theta_i|\mu(\theta_i), h_{i,t-1}) = \frac{Pr(h_{i,t-1}|\gamma(\theta_i)) f(\theta_i|\mu(\theta_i))}{\int_0^1 Pr(h_{i,t-1}|\gamma(\theta_i)) f(\theta_i|\mu(\theta_i)) d\theta_i} \tag{21}$$

And using the posterior degree of belief and distribution, we can get the Bayesian expectation of firm i success rate with the pair $\gamma(\theta_i)$ after period 1:

$$q_{i,t}^E = Pr(S_{i,t}) = \sum_{i=1}^{m} Pr(\mu(\theta_i)|h_{i,t-1}) \int_0^1 Pr(S_{i,t}|\gamma(\theta_i)) f(\theta_i|\mu(\theta_i), h_{i,t-1}) d\theta_i \tag{22}$$

Intermediary bank provide a mass of n loans to firms in total, the number of firm is normalized to 1. Since there are 2^t series of history in period t, as t is sufficiently large, the intermediary bank's expectation of firm's success probability will also follows a unit distribution for the integral $[\overline{q}_1, 1]$, though firm will never reveal their true type, their histories will indicated their type with very small error if t is large enough.

Based on the belief of firm's type, intermediary bank will be selective on firm in order to achieve profit maximisation. The intermediary bank simultaneously decide loan offer to both type of project. If $\overline{q}_1 \geq q_{i,t}^E$, the firm's expected probability of success falls below threshold $\overline{q}_1$ which implies a high level of risk, the bank will not provide loan for any project to that firm. If $\overline{q}_2 \geq q_{i,t}^E > \overline{q}_1$ which implies a acceptable level of risk, the bank will provide loans for the basic project to the firm

but will not provide loan to the additional project. If $q^E_{i,t} > \overline{q}_2$ which implies a low level of risk, the bank will provide loans for both basic and additional project to firm i. In each period, the intermediary bank's portfolio consist $(1-\overline{q}_1)n$ loans for the basic project and $(1-\overline{q}_2)n$ loans for the additional project. Since $(1-\overline{q}_2)n$ units of funds are lend to expansion project, using $q_1 n$ units of funds. This implies $\overline{q}_2 = 1-\overline{q}_1$.
Same as the original model, each investors are endowed with same amount of wealth l where $l > 1$ in each period and they make decisions on the investment on deposit d, bank equity e and risk free asset A.

$$l = d + e + A \tag{23}$$

The intermediary bank's net profit is equal to the earning on interest minus the promised return on deposit pay to the investors.

$$\pi_B = in - rd \tag{24}$$

The intermediary banks offer type specific interest rate $i(q^E_{i,t}, y)$ depends on banks updated expectation of firm's type and the type of project. The intermediary banks earn interest only if the project is success, the intermediary bank's total earning on interest is

$$i = \int_{\overline{q}_1}^{1} q^E_{i,t} i(t, y_1) dq^E_{i,t} + \int_{\overline{q}_2}^{1} q^E_{i,t} i(t, y_2) dq^E_{i,t} \tag{25}$$

Follow Keuschnigg and Kogler (2020), here introduce minimum capital requirement on intermediary bank's constraint though the effect of bank capital such as risk buffer discussed in the section of literature review is not considered in the model. Let k be the capital required on each basic project and $(1-w)k$ be the capital required on each additional project where $w \leq 1$. Since the expected success probability of the additional project is higher than the basic project, it will require a relative lower capital. The intermediary bank's capital must satisfy:

$$e \geq (1 - w\overline{q}_1)nk \tag{26}$$

Since there do not exist a cost of reallocation, the capital requirement is decreasing with the increase of minimum success rate required for the bank of the basic project. Along with the increase of success rate require, more funds will be offer to expansion project which has a higher success probability and reduce the capital requirement. I followed the assumption in Keuschnigg and Kogler (2020), the return of investment satisfy:

$$y_1 > 2r > y_2 > r \tag{27}$$

Since the type of firm follows a uniform distribution, interest charge by the intermediary bank is $2r$ and promise invest a return rn in period 1 with full uncertainty,. Along with intermediary bank belief updating, the belief of type is getting closer to the true type, the interest premium decreasing to zero. Therefore it is always optimal for firm to accept the offer if it has been offered a loan since the firm will either yield $\theta_i(y_1 - i)$ or 0. In the case with full uncertainty, the return of project if success is higher than the required interest. The bank expected firm profit for firm accept the loan offer is:

$$\pi^E_F = \int_{\overline{q}_1}^{\overline{q}_2} q^E_{i,t}(y_1 - i(t, y_1)) dq^E_{i,t} + \int_{\overline{q}_2}^{1} q^E_{i,t}(y_1 + y_2 - i(t, y_1) - i(t, y_2)) dq^E_{i,t} \tag{28}$$

Regards to agency problem, I also follow Keuschnigg and Kogler (2020) approach, the equity holders need to offer part of the profit $(1-z)\pi_B$ as compensation to the the intermediary bank

and the equity holders receive the rest of profit $z\pi_B$ as dividend. The part of compensation needs to satisfy that:

$$(1-z)\pi_B \geq (1-p)\pi_B \iff z \leq p. \tag{29}$$

For investor, the profit is equal to the return of investment on deposit d, risk free asset A and equity e. In equilibrium, the investors should be indifferent between these three products implies that

$$\begin{aligned} \pi_I &= re + rd + rA = rl \\ re &= z\pi_B \end{aligned} \tag{30}$$

In every period, the intermediary banks observe the previous histories and update their belief on firms' types, they offer loans to the firm with expected high chance of success, the optimal selection of threshold $\overline{q}_1$ maximize the expected bank's interest income subject to capital constraint

$$i = \max_{\overline{q}_1} \int_{\overline{q}_1}^{1} q_{i,t}^E i(t,y_1) dq_{i,t}^E + \int_{\overline{q}_2}^{1} q_{i,t}^E i(t,y_2) dq_{i,t}^E + \lambda(e-(1-w\overline{q}_1)nk)/n \tag{31}$$

By $\frac{di}{d\overline{q}_1}$ we have the optimal interest for basic project $i(t,y_1) = \frac{(1-\overline{q}_1)i(t,y_2)+\lambda wk}{\overline{q}_1}$ and for expansion project $i(t,y_2) = \frac{(1-\overline{q}_2)i(t,y_1)-\lambda wk}{\overline{q}_2}$. Since in equilibrium, the investor must be indifferent of selecting three investment, implies that the return on share must at least not smaller than the required return on equity, the surplus S satisfy:

$$S = \max_{z,e,n} z\pi_B - re \geq 0 \tag{32}$$

$$\text{s.t.} \quad (1-z)\pi_B \geq (1-p)\pi_B \tag{33}$$

$\frac{dS}{dz} = (1-\nu)\pi_B = 0$, implies the shadow price $\nu = 1$ and $z = p$, for profit maximization, the share equity holders compensate bank is equal to the bank's expect gain from the diversion. Since $\pi_B = i - rd = i - rn + re$ and $di/de = \lambda$, $\frac{dS}{de} = \lambda = \frac{(1-z)r}{z}$. $\frac{dS}{dn} = i - r - \frac{\lambda e}{n} = 0$. As the capital constraint bind, $e = (1-w\overline{q}_1)kn$. Combine together,

$$i = r + \lambda(1-w\overline{q}_1)k, \quad \lambda = \frac{1-p}{p}r \tag{34}$$

The interest income is require to equal to the risk free interest r and the cost of capital required for a loan. The shadow price is same as the one in Keuschnigg and Kogler (2020) since the agency problem remains. This shadow price reflects the different cost of equity compare with deposit. If the probability of bank diverting is not zero, equity holders must pay some amount of funds to the intermediary bank to avoid diverting, so the bank will need to earn more profit that ensure after transfer a share to the bank, the rest profit is still equivalent to the return of deposit. The increase of bank's diversion probability increase the relative shadow price and thus demand a higher interest income.

Under a competitive bank loan market, the intermediary bank selection of threshold and interest will need to achieve firm profit maximization, otherwise the intermediary bank's competitor can always attract firms with a lower level of interest offer.

$$\pi_F^E = \max_{\overline{q}_1} \int_{\overline{q}_1}^{\overline{q}_2} q_{i,t}^E y_1 dq_{i,t}^E + \int_{\overline{q}_2}^{1} q_{i,t}^E (y_1+y_2) dq_{i,t}^E - (r + \lambda(1-w\overline{q}_1)k) \tag{35}$$

The optimal threshold satisfied

$$\overline{q}_1^* = \frac{y_2 + \lambda wk}{y_1 + y_2}, \quad \overline{q}_2^* = \frac{y_1 - \lambda wk}{y_1 + y_2} \tag{36}$$

The optimal threshold is depend on the cost of equity, if the relative cost of equity is too high compare with the cost of deposit, $\overline{q}_2^*$ will decreases since the intermediary bank will tend to offer more loans only on firms' expansion project with high success probability since these loans require low capital reserve.

Proposition 1. In market equilibrium, the optimal allocation of loans will achieve higher aggregate output and market efficiency in the absence of reallocation cost.

Proof. Compare the optimal threshold in this model and in Keuschnigg and Kogler (2020) agency cost:

$$\frac{y_2 + \lambda wk}{y_1 + y_2} > \frac{(1-c)y_2 - \theta b}{y_1 + (1-c)^2 y_2}$$

$$\frac{y_1 - \lambda wk}{y_1 + y_2} < \frac{y_1 + (1-c)\theta b}{y_1 + (1-c)^2 y_2}$$

Compare with the result in Keuschnigg and Kogler (2020), with the same shadow price structure, the absent of credit reallocation and the cost of withdraw funds reduce the demand capital therefore result a higher success probability required on the basic project and more loans are offer to the expansion project and therefore increase aggregate productivity. The impact of cost difference between equity and deposit still exist, for the policy maker, it can be improved by strengthening the protection of equity holders as discussed in LA PORTA et al. (1997), Giannetti (2003) and Kvaløy and Olsen (2009).

The closed-form solutions for interest rate can be obtained combine $i = \int_{\overline{q}_1}^1 q_{i,t}^E i(t, y_1) dq_{i,t}^E + \int_{\overline{q}_2}^1 q_{i,t}^E i(t, y_2) dq_{i,t}^E$ with $i = r + \lambda(1 - w\overline{q}_1)k$. The optimal threshold and the optimal interest rate implies that under a competitive market, the competition force the intermediary banks to sacrifice a proportion of loan income to ensure entrepreneurs reach to the break even.

4.3 Conclusion

In this section, I present an extended model of Keuschnigg and Kogler (2020) which incorporates belief updating and a dynamic environment and can be used as a baseline model for future study. I first illustrate the Bayesian belief updating process for a type that follows a uniform distribution on $[0, 1]$. I consider a situation when time reaches t, the intermediary banks fully update their belief and have the knowledge of the firm's true type and characterize the equilibrium. Compared with the result in Keuschnigg and Kogler (2020), with the existence of agency cost and the absence of the cost of reallocation within a period, this results in a higher aggregate output and resource concentration on highly productive firms. The explanation is that in this model, offering the same sized loan to highly productive firms will reduce the costly capital required compared to offering it to less productive firms, therefore the loan requested by the highly productive firms is preferred by the intermediary bank.

5 Future Work

The discussion I present in the paper is an unfinished work and will requires future study. My research goal for the current stage is to study the dynamic behavior between intermediary bank and firm in a market characterized by asymmetric information. The dynamic settings are important since they could allows to capture the strategies or decision changes therefore the indirect effects when economic factor changes and result in a more comprehensive analysis on the economic impact of each factor. However, this does involves difficulties to develop a dynamic model incorporates both bank and firm behavior and indeed require much more time consuming than I have. The contribution I made in this paper is mainly on technical solution for some of the difficulties, I incorporate belief updating process and in a model that characterizes some of the bank behaviors and this can be use as one of the baseline model for the future study. Still, many tasks remain for the future study. The first is to consider the firm dynamic, given the intermediary bank's interest setting strategy and belief updating process, firms could use signals to reveal or mimic their type. And if firm do not consume all the profit, but instead it uses a part to invest in its production technology and gain advantage in the loan competition. It would be one of the source result in dispersion of firm growth speed and the bank's preference on high productive firm may result in a case that the loans are over concentrate on the firm which bank believe is good before period t which harm the good firm with bad luck. Also, for the firm side, one need to be considered is the characterization of long term relationships discussed in Boot and Thakor (1994) and Petersen and Rajan (1995). Since before the period t, intermediary banks have not yet form the accurate belief on the firm's type, to prevent harming the good firm with bad luck, intermediary bank could reduce interest offered and compensate it in the future with beliefs are truly formed and result in a different structure on the interest rate.

6 Conclusion

In this dissertation, I illustrate some influential discussions in the previous literature mainly related to the topic of intermediary bank behavior under asymmetric information. The structure and motivations of debt contracts, the role of bank capital, the incentives for maintaining long term relationships between intermediary banks and firms, as well as the agency problem and the solution for policymakers. I present a detailed review of Keuschnigg and Kogler (2020) and discuss how the agency cost and capital reallocation cost create distortions in intermediary banks' behavior. Then I move on to an extension of Keuschnigg and Kogler (2020) which would be one of the baseline models adopting belief updating and dynamic features for future study. I illustrate the technical solution and the differences in results between these two versions. The next step of work is to consider the period before t when intermediary banks have not truly known the firms' type and characterize the impact of long term relationships as discussed in Boot and Thakor (1994) and Petersen and Rajan (1995).

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